A STUDY OF ROBOETHICS IN THE AUTONOMOUS VEHICLE SECTOR IN DELHI-AGRA REGION - CURRENT STATUS, ETHICAL FRAMEWORKS, CHALLENGES, AND POTENTIAL SOLUTIONS

SYNOPSIS

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INTRODUCTION

Recent technological advances have aided the expansion of robot applications in society. Automotive, defence, healthcare, transportation, education, and other industries sectors have all experienced improvements in their capabilities, moving from being pre-defined machines that had to execute specific tasks in specific circumstances to being autonomous agents that could make their own decisions. A new area of applied ethics known as "RoboEthics" has emerged as a result of research into human-robot interaction. It covers moral concerns pertaining to the design, usage, and misuse of robots (Veruggio, 2006). Autonomous vehicles (AVs) are one of the major commercialized sectors that demonstrate this technological revolution. The adoption of AV is expected to result in better transportation experiences, including lower prices, fewer fatal collisions, more time for drivers to relax, mobility for non-drivers, and less pollution (Liljamo et al., 2018). Despite these advantages, AV-related incidents cannot be completely avoided. Similar to human drivers, AVs make judgements that could have life-or-death repercussions and may encounter dilemmas like the "Trolley Problem" (discussed in Point E section 1.1) (Nyholm &Smids 2016). Developing frameworks to enhance the safety features of AVs raises concerns about ensuring data privacy and safeguards from hacking, broken communication, particularly in remote areas, and inaccurate data, as in the case of Google Maps, as well as understanding whether these guidelines would be universally applicable across borders.

First, concepts important from the perspective of the present research are discussed.

1.1 Definitions:

(A) Robots:

According to ISO 8373:2012, a robot is an "actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks." They may be categorized into Industrial and Service Robots.

Industrial robots: -

In accordance with ISO, Industrial robots are "Automatically controlled, reprogrammable, multipurpose manipulators programmable in three or more axes, which can be either fixed in position, or mobile for use in industrial automation applications". Automated workstations, automated arms, and production lines are some examples.

Service robots: -

According to ISO, a "service robot" is a robot that "performs useful tasks for humans or equipment, excluding industrial automation applications." Application areas for service robots include exoskeletons/artificial bodies such as artificial limbs (legs, arms), military & security such as PackBot and BigDog, which assist soldiers in moving heavy equipment, education such as educational 3D printers and even robot teachers such as EMYS, entertainment, and self-driving cars.

(B) Ethics:

According to the Oxford Dictionary of Philosophy, Ethics is "the branch of philosophy concerned with the evaluation of human conduct."

(C) RoboEthics:

RoboEthics is an applied ethics whose objective is to develop scientific/cultural/technical tools that can be shared by different social groups and beliefs. These tools aim to promote and encourage the development of Robotics for the advancement of human society and individuals, and to help prevent its misuse against humankind (Veruggio, 2002).

(D) Autonomous Vehicles (AVs):

Autonomous Vehicles (AVs) are vehicles that are capable of driving themselves without human intervention. According to the Society of Automotive Engineers (SAE) International Standard, there are 6 levels of driver assistance technologies:

Level 0: No automation – All tasks are performed by the driver.

Level 1: Driver Assistance – Stand-alone vehicle components such as Electronic Stability Program (E.S.P) or Automatic Braking are present.

Level 2: Partial Automation – combined automated features such as steering/acceleration, i.e., lane-keeping, and adaptive cruise control are present. However, the driver must always be involved in the driving and he/she must monitor the environment.

Level 3: Conditional Automation- The driver can fully cease control of some of the important functions of the vehicle in certain conditions, but he/she must remain ready to take control of the vehicle at all times with advance notice.

Level 4: High Automation –The vehicle can execute all the driving functions. The option to control the

vehicle may or may not be there with the driver.

Level 5: Full Automation – The vehicle is able to perform all functions related to driving, under all situations and conditions.

E) Trolley Problem:

The Trolley Problem is an ethical and moral philosophy thought exercise that examines the challenges of forming moral judgments in cases involving human life and moral quandaries. It depicts a fictitious situation where a person is placed in the role of an observer or a decision-maker who must pick between two morally difficult possibilities.

In the classic Trolley Problem scenario, a runaway trolley (or tram) hurtles down a track toward a group of five immobile passengers. By moving the tram to a different track with just one person on it, the observer has the ability to change the situation. The choice is between intervening by rerouting the tram to save the five people but endangering the life of the one person on the alternate track, or doing nothing and letting the tram follow its original path, which would result in the deaths of the five people.

1.2 Importance of RoboEthics

Robotics brings together two cultures: science and humanities. The growth of robotics and its expanding range of applications creates ethical issues, particularly when it comes to how human-robot interaction (HRI) will be impacted like assistive robots, elder care robots, social robots, entertainment robots, etc. Involving robots in human surroundings presents fundamental ethical concerns of safety, ethics, and the economy.

The goal of the emerging field of RoboEthics is to give robots ethical guidelines or methods for handling any ethical dilemmas they may face (Anderson and Anderson, 2011). It is an effort to comprehend how robot technology will impact our civilization in terms of ethics. It is not the ethics of robots, but the human ethics of robot designers, manufacturers, and users. Its goal was to advance and stimulate robotics research and development for the benefit of advancing human society (Veruggio, 2002; Veruggio, 2005).

Due to the illustration of our recent history, the significance and urgency of RoboEthics have grown in recent years. Nuclear physics, bioengineering, and computer science are three areas of science and technology that have already had to deal with the ramifications of their ethics and practical use of their

knowledge. Recent dramatic incidents, public outcry, and effects have pushed for either a complete halt to research and applications or stringent regulation, which has given rise to words like "Bioethics," "Neuroethics," "Digital Media Ethics," and "Cyberethics" in the professional literature.

Robotics' transformation from a purely utilitarian tool to a social robot as a result of technological advancements will have a significant impact on societal values and conventions as well as the evolution of robot-human interaction (Šabanović, 2010). The design, operation, application, use, and evaluation of robots will be impacted by social and cultural aspects (norms, morality, beliefs, etc.). RoboEthics will aid in the long-term, ethical, and profitable coexistence of humans and robots at increasing degrees of integration and comprehension (Westerlund, 2020).

The standardisation of RoboEthics requires the accomplishment of some fundamental steps which give rise to the Five fundamental questions about RoboEthics.

1.What role does RoboEthics play in shaping the public perception and acceptance of AVs?

2.How do the diverse approaches of different countries contribute to the achievement of addressing RoboEthics in AV technology?

3.How can RoboEthics contribute to fostering responsible AV deployment?

4.To what extent are AVs considered as moral agents, and how is this concept evolving in the field of RoboEthics?

5.Are there international standards or agreements on RoboEthics applicable to AVs?

This research aims to examine the existing state of RoboEthics within the global autonomous vehicle (AV) sector. It specifically focuses on investigating the ethical hurdles involved in introducing AVs into the Indian markets. Furthermore, the study seeks to explore ethical frameworks that utilize simulation tools, all while taking into account the unique context of the Indian Transportation System.

2. AV Current Status - International and India: Progress, Challenges, and New Technologies

2.1 AV Current Status - International

The autonomous vehicle (AV) industry has seen significant growth and development globally, driven by digitalization, sustainability policies, and changes in consumer preferences. Several prominent companies are actively working on autonomous technology, pushing the boundaries of what is possible in the automotive sector.

Here are some notable developments from major companies:

Alphabet Inc. (Google): Waymo, a subsidiary of Alphabet, has achieved a significant milestone by completing 20 million miles of level 5 autonomous driving tests. Level 5 refers to full automation, where the vehicle can handle all driving tasks without human intervention.

General Motors: GM's autonomous vehicle division, Cruise, is actively developing level 3 and level 4 automotive driver-assist technology. Level 3 allows the vehicle to handle certain driving tasks autonomously but still requires a human driver as a backup, while level 4 provides high automation where the vehicle can operate without human input within certain environments.

Mercedes-Benz: Daimler's Intelligent Drive system empowers vehicles to detect, recognize, and avoid obstacles, allowing the car to brake and steer around them at high speeds in both fully autonomous and semi-autonomous settings.

Tesla: Tesla's Autopilot technology, available in their Model S and Model X vehicles, claims to offer autonomy ranging from level 3 to level 5, depending on the driving situation. However, it is essential to note that the use of the term "Autopilot" has generated some controversy and calls for clarifying the capabilities and limitations of the technology.

Volkswagen and Audi: Both companies have made significant progress in developing their autonomous vehicle division known as Traffic Jam Pilot, aiming to tackle congestion and improve the driving experience during heavy traffic conditions.

Moreover, several other leading car manufacturers, such as BMW, Ford, Kia, Hyundai, Honda, Toyota, Volvo, and Nissan, have introduced automotive technologies ranging from level 2 to level 4. These technologies include features like emergency braking, smart parking, accident warning, and semi-automatic pilot driving.

2.2 AV Current Status – India

Despite the fact that India is the world's third-largest automotive market, with a market value of more than $100 billion and a GDP contribution of 2.3% (Mehra, 2021), progress in the autonomous vehicle sector has been slow. The Motor Vehicles (Amendment) Act, 2019, states that AV testing is permitted in India. This is corroborated by the fact that India ranks 29th out of 30 countries in KPMG's 2020 Autonomous Vehicle Readiness Index (Kumar, 2019). Prototype AVs are being tested by well-known

companies like Mahindra and TATA Motors along with other start-ups like Flux Auto, Scouto, and Minus Zero.

The adoption of AVs in India faces numerous challenges. These challenges include the lack of adequate road infrastructure, an abundance of potholes, a poorly planned road network, the absence of barriers, missing directional and speed information, traffic lights, and appropriately placed road rules, haphazard speed breakers, poor road mapping, and insufficient public adherence to traffic laws. Additionally, the coexistence of different types of vehicular traffic and non-lane driving further complicates the widespread adoption of AVs.

Addressing ethical challenges is also crucial for the successful integration of AVs into society. Key techno-social ethical issues include Safety (McBride, 2016), Security (DFT and CPNI, 2017), Privacy (Wachter et al., 2017), Transparency (algorithmic and social fairness) (Goodman and Flaxman, 2017), Responsibility, Accountability (Dodig-Crnkovic and Persson, 2008), Reliability, Trans-disciplinarity systemic approach (stakeholders' involvement) (Eckstein and Schwalm, 2016), Social Trust, Quality assurance (Pelliccione et al., 2017), Environmental sustainability and Justice (Pillath, 2016), need to be addressed. As the new technology is being tested and gradually allowed on the roads under controlled conditions, the focus should be on discussing ethical issues and challenges to introducing AVs as a global transportation system. It is time to start an investigation into the various ethical challenges surrounding AVs (Ethics Commission, 2017).

2.3 Role of New Technologies in AVs

With the growth of new technologies, such as the Internet of Things (IoT), 5G connectivity, and artificial intelligence (AI), has significantly impacted AVs. These technologies enable AVs to access real-time data and utilize inertial navigation systems (INS) to better identify operational issues and comprehend environmental circumstances. In order to communicate with their surroundings and other vehicles, AVs use short-range vehicle-to-vehicle (V2V) and vehicle-to-everything (V2X) communications. This enables them to have advanced and uncompressed ADAS (Advanced Driver Assistance Systems) and vehicular ad-hoc networks (VANETs), which can help them gain traction in the market (Piao & McDonald, 2008). However, the increased connectivity also brings forth challenges related to privacy and cybersecurity for AVs. Vehicle connectivity, in conjunction with all-connected infrastructure, raises

possible vulnerabilities to hacking, unethical surveillance, vehicle theft, remote hijacking, and new chances for misuse/mismanagement of private data. Addressing these security and privacy concerns effectively is crucial to ensuring the global adoption and deployment of AVs.

3. Ethics – Types and Theories:

It is a branch of philosophy that examines the evolution of human behaviour. The word "ETHICS" is derived from the Greek word "Ethikos," which implies character. The literature of the Sumerian and Egyptian civilizations contains ethical concerns about social behaviour. A formal framework or set of guidelines for conduct that are formally adopted by a group of individuals. Society at a certain time and place decides what is morally right to do. This is also governed by professional and legal standards. According to the late Italian philosopher Remo Bodei (Blackburn, 1996), ethics is more concerned with our interactions with other people and society as a whole, whereas morality is more concerned with our ties with ourselves and our conscience. Simply said, morality is the assessment of whether a course of action, way of life, or decision is right or wrong, and ethics is the study of the criteria we employ to assess such actions. The discipline of science known as ethics focuses on morality.

Nowadays, it is accepted that there are three main fields of research in ethics:

1. Meta-ethics, which deals with the theoretical significance and framework of moral claims and how their potential truth values might be assessed. The three well-known meta-ethical frameworks are relativism, pluralism, and absolutism.

2. Normative ethics, which focuses on the methods for deciding what is morally right to do. Utilitarianism, Contractarianism, Deontologism, and Kantianism are well-known Normative frameworks.

3. Applied ethics, which deals with what a person is required (or allowed) to do in a particular circumstance or field of endeavour. Engineering ethics, bioethics, geo-ethics, public service ethics, and corporate ethics are just a few of the numerous specialized topics in the study.

3.1 Theories of Ethics

A. Utilitarianism:

According to John Stuart Mill (1998), the only legitimate and universally acceptable outcome of human acts is the pursuit of pleasure or happiness and the avoidance of sorrow. If and only if the total utilities

provided by a particular action exceed the total utilities created by any other action the agent could have carried out in its stead, then that action is ethically acceptable.

The founder of utilitarianism, Jeremy Bentham (1996), outlined a set of principles that are only based on values and do not take environmental factors or the nature of the act itself into consideration.

B. Contractarianism:

The term "contractarianism" refers to a particular moral or political theory that uses the concept of a contract (or, in less formal terms, mutual agreement) between individuals to explain the nature and the force of the rules that apply to them, primarily the rules guiding their interactions or subsequent behaviours (Cudd & Eftekhari, 2000). According to Scanlon, if a set of general guidelines for behaviour regulation that no one could reasonably reject as the basis for informed, voluntary, widespread agreement would ban its performance under the current circumstances, then that conduct is wrong (Suikkanen, 2007).

C. Deontologism:

Instead of concentrating on the outcome, the deontologist examines the process and the motivation behind actions. This kind of ethics is duty-based. Deontological or duty-based ethics, as exemplified by Kant's theory, judge morality by focusing on the nature of actions and the agents' will rather than the outcomes (Beauchamp, 2001).

Regardless of the result, the actor's motivations decide whether an act is moral. Deontology only demands that people uphold the law and carry out their obligations (Waller, 2005).

D. Kantianism

Immanuel Kant, a German philosopher, is the founder of the philosophical philosophy known as "Kantianism" According to this, an action is only moral if it is (a) driven by a sense of duty and (b) its tenet can be rationally willed to be a general, unchanging law (Kant and Teale, 1951).

The idea that morality is founded on reason rather than on subjective sentiments or desires is one of Kantianism's core ideas (Brinton, 1967). Kant's ethical theory was founded on the idea that moral action should be decided by reason (Singer, 2010).

E. Relativism

According to relativism, knowledge, truth, and morality are relative to the individual or cultural context

in which they are formed rather than being absolute truths. Cultural relativism, moral relativism, and epistemological relativism are just a few examples of the various types of relativism (Baghramian, 2004). The concept of moral relativism involves the variations in moral standards among individuals and cultures. According to epistemic relativism, there are only relative normative beliefs, justification, and rationality standards, not any absolute ones (Swoyer, 2003). According to the theory of cultural relativism, distinct cultures have unique beliefs, values, and customs that cannot be compared or contrasted. So, moral and ethical standards, as well as social norms and behaviours, are contingent upon the culture in which they are practised (Baghramianand Carter, 2015).

F. Absolutism

The philosophical idea that certain moral standards, ideals, or principles apply to everyone regardless of their background or culture is known as absolutism. According to absolutism, all people and cultures, regardless of their views or ideals, are subject to objective, inescapable rules that determine what is right and wrong (Ess, 2017).

G. Pluralism

A philosophical and political position known as pluralism defends and values diversity, individuality, and a range of viewpoints in society. According to pluralism, there are numerous perspectives on the world, and this diversity should be appreciated and acknowledged rather than repressed or disregarded (Ess, 2017).

H. Egoism

Egoism is a philosophical perspective that emphasises the significance of self-interest and personal gain as the fundamental driving forces behind human conduct. According to egoism, people should act in their own best interests rather than attempting to advance the interests of other people or society as a whole (Brink, 2007; Regis, 1980).

I. Altruism

The act of voluntarily assisting others without anticipating compensation is referred to as altruism. It refers to deeds that are done for the good of others, even if they cost or sacrifice oneself. Many cultures and societies place a high value on altruism because it is frequently regarded as a beneficial quality (Heubner & Hauser, 2011).

4. Literature Review

In this section, the review of literature is discussed to understand RoboEthics that are related to AVs and focus on real-world ethical social/technical challenges faced by AVs, Ethical Frameworks potentially to be used and the development of the Autonomous Vehicle market in India.

4.1 Taxonomy of Literature Review

A review of the literature was conducted by using search strings and words like "RoboEthics", "Autonomous Vehicles", "Self-Driving Cars", "Automated Driving System", "Challenges and Benefits", "Driver Less Car" and "Indian Self-Driving Cars".

Table 1 Key Words Classification

Search Strings	Number of Documents
RoboEthics	1,180
Autonomous Vehicles	180
Self-Driving Cars	241
Automated Driving System	7,090
Challenges and Benefits of Driver-Less Cars	1,140
Indian Self-Driving Cars	5,081

An analysis of the title and abstract for relevance to the focus area of RoboEthics yielded 45 papers which were studied for the purpose of literature review.

Table 2 Literature Review Classification

Particulars	Number of Paper
1. The focus of the paper	
Ethical Social/Technical Challenges	30
Ethical Frameworks	8
Autonomous Vehicle Market in India	7
2. Context of the paper	
Indian	8
Foreign	37
3. Type of Data for analysis	
Qualitative	36
Quantitative	9
4. Research Design	
Exploratory	8

Descriptive	8
Analytical	29

Table 2 highlights the taxonomy of the focus area and the number of papers frequently written. 30 papers studied the role that Ethical Challenges played in the social acceptance of AVs, 8 papers studied the Ethical Frameworks that can be used by AVs and 7 papers studied the current status of the AVs in India. 37 out of 45 were related to the international context. 36 studies were Qualitative in nature and 9 studies were Quantitative in nature. There are 29 papers that are most likely to be analytical, 8 papers that seem to be exploratory, and 8 papers that appear to be descriptive.

Title	Category	Source	Focus Area			Context		Data Type		Methodology		
			Social/Technical Ethical Challenges	Ethical Frameworks	Automotive Vehicle Market in India	Indian	Foreign	Qualitative	Quantitative	Exploratory	Descriptive	Analytical
Why ethics matters for autonomous cars, Lin, P. (2016).	Book Chapter	Autonomous driving: *Technical, legal and social aspects* Springer	✓				✓	✓				✓
A Code of Ethics for Self-Driving Vehicles. Gleadow, M. (2022)	Conference Paper	Wellington Faculty of Engineering Ethics and Sustainability	✓				✓	✓				✓
Inclusion of Ethical Aspects in Multi-criteria Decision Analysis. Sapienza, G., Dodig-Crnkovic, G., & Crnkovic, I. (2016).	Conference Paper	Decision-Making in Software Architecture	✓				✓		✓			✓
Towards moral autonomous systems. Charisi, V., Dennis, L., Fisher, M., Lieck, R., Matthias, A., Slavkovik, M., ... &Yampolskiy, R. (2017).	Research Paper	AI, Ethics, and Society	✓				✓	✓		✓		
Ethics and self-driving cars. Santoni de Sio, F. (2016).	White paper	Automated Driving Systems.	✓				✓	✓				✓
Real-world ethics for self-driving cars. Holstein, T., Dodig-Crnkovic, G., & Pelliccione, P. (2020)	Research Paper	ACM/IEEE	✓				✓	✓		✓		
Ethical and social aspects of self-driving cars. Holstein, T., Dodig-Crnkovic, G., & Pelliccione, P. (2018)	Research Paper	Philosophy & Technology	✓				✓	✓		✓		
Steps Toward Real-World Ethics for Self-Driving Cars: Beyond the Trolley Problem. Holstein, T., Dodig-Crnkovic, G., &	Research Paper	Machine Law, Ethics, and Morality in the	✓				✓	✓				✓

Title	Category	Source	Focus Area			Context		Data Type		Methodology		
			Social/Technical Ethical Challenges	Ethical Frameworks	Automotive Vehicle Market in India	Indian	Foreign	Qualitative	Quantitative	Exploratory	Descriptive	Analytical
Pelliccione, P. (2021).		Age of Artificial Intelligence										
Ethical issues in focus by the autonomous vehicles industry. Martinho, A., Herber, N., Kroesen, M., & Chorus, C. (2021).	Research Paper	Transport reviews	✓				✓	✓				✓
Exploring expert perceptions about the cyber security and privacy of Connected and Autonomous Vehicles: A thematic analysis approach. Liu, N., Nikitas, A., & Parkinson, S. (2020).	Research Paper	Transportation research part F: traffic psychology and Behaviour,	✓				✓	✓			✓	
The future of transportation: ethical, legal, social and economic impacts of self-driving vehicles in the year 2025. Ryan, M. (2020).	Research Paper	Science and Engineering ethics	✓				✓	✓				✓
Responsibility and the moral phenomenology of using self-driving cars. Coeckelbergh, M. (2016).	Research Paper	Applied Artificial Intelligence	✓				✓	✓				✓
Artificial intelligence, responsibility attribution, and a relational justification of explainability. Coeckelbergh, M. (2020).	Research Paper	Science and Engineering ethics	✓				✓	✓				✓
Robot enhanced therapy for children with autism disorders: Measuring ethical acceptability. Coeckelbergh, M., Peca, A., Simut, R., Costescu, C., Pintea, S., David, D., & Vanderborght, B. (2016).	Research Paper	IEEE Technology and Society Magazine	✓				✓		✓			✓
Personal robots, appearance, and human good: a methodological reflection on	Research Paper	International Journal of Social	✓				✓	✓				✓

Title	Category	Source	Focus Area			Context		Data Type		Methodology		
			Social/Technical Ethical Challenges	Ethical Frameworks	Automotive Vehicle Market in India	Indian	Foreign	Qualitative	Quantitative	Exploratory	Descriptive	Analytical
roboethics. Coeckelbergh, M. (2009).		Robotics										
Is Driverless Car Another Weiserian Mistake? Alavi, H. S., Bahrami, F., Verma, H., & Lalanne, D. (2017)	Research Paper	ACM Conference Companion Publication on Designing Interactive Systems	✓				✓	✓				✓
Autonomous automobiles: The social impacts of driverless vehicles. Bissell, D., Birtchnell, T., Elliott, A., & Hsu, E. L. (2020).	Research Paper	Current Sociology	✓				✓	✓		✓		
Self-driving cars and engineering ethics: The need for a system-level analysis. Borenstein, J., Herkert, J. R., & Miller, K. W. (2019).	Research Paper	Science and Engineering ethics	✓				✓	✓				✓
Self-driving cars: Ethical responsibilities of design engineers. Borenstein, J., Herkert, J., & Miller, K. (2017).	Research Paper	IEEE Technology and Society Magazine	✓				✓	✓				✓
Machine ethics and automated vehicles. Goodall, N. J. (2014).	Research Paper	Road Vehicle Automation Springer	✓				✓	✓				✓
Ethical decision-making during automated vehicle crashes. Goodall, N. J. (2014).	Research Paper	Transportation Research Record	✓				✓	✓				✓
Away from trolley problems and toward risk management. Goodall, N. J. (2016).	Article	Applied Artificial Intelligence	✓				✓	✓				✓
Can you program ethics into a self-driving	Article	IEEE Spectrum	✓				✓	✓				✓

Title	Category	Source	Focus Area			Context		Data Type		Methodology		
			Social/Technical Ethical Challenges	Ethical Frameworks	Automotive Vehicle Market in India	Indian	Foreign	Qualitative	Quantitative	Exploratory	Descriptive	Analytical
car? Goodall, N. J. (2016).												
Autonomous vehicles: challenges, opportunities, and future implications for transportation policies. Bagloee, S. A., Tavana, M., Asadi, M., & Oliver, T. (2016).	Research Paper	Journal of Modern Transportation	✓				✓	✓				✓
Automotive architecture framework: The experience of Volvo cars. Pelliccione, P., Knauss, E., Heldal, R., Ågren, S. M., Mallozzi, P., Alminger, A., & Borgentun, D. (2017).	Research Paper	Journal of Systems Architecture	✓				✓	✓			✓	
The ethics of crashes with self-driving cars: A roadmap, I. Nyholm, S. (2018).	Research Article	Philosophy Compass		✓			✓	✓				✓
The ethics of accident algorithms for self-driving cars: An applied trolley problem? Nyholm, S., & Smids, J. (2016).	Research Article	Ethical theory and moral practice		✓			✓	✓				✓
The ethics of crashes with self-driving cars: a roadmap, II. Nyholm, S. (2018).	Research Paper	Philosophy Compass		✓			✓	✓				✓
Self-driving car acceptance and the role of ethics. Karnouskos, S. (2018).	Research Paper	IEEE Transactions on Engineering Management		✓			✓		✓	✓		
User Acceptance and Ethical Decision-Making of Fully Autonomous Forms of Shared Mobility. Esch, J. V. (2021).	Research Paper	Transportation Research Record		✓			✓		✓	✓		
Ethics of Self-driving Cars: A Naturalistic Approach. Arfini, S., Spinelli, D., & Chiffi, D. (2022).	Research Paper	Minds and Machines		✓			✓	✓				✓

Title	Category	Source	Focus Area			Context		Data Type		Methodology		
			Social/Technical Ethical Challenges	Ethical Frameworks	Automotive Vehicle Market in India	Indian	Foreign	Qualitative	Quantitative	Exploratory	Descriptive	Analytical
Public opinion about self-driving vehicles in China, India, Japan, the US, the UK, and Australia. Schoettle, B., & Sivak, M. (2014).	Research Paper	University of Michigan, Ann Arbor, Transportation Research Institute.			✓	✓			✓		✓	
Self-driving cars. Daily, M., Medasani, S., Behringer, R., & Trivedi, M. (2017).	Research Paper	Computer			✓	✓		✓			✓	
Top 10 Self-Driving Car Companies in India to Overshadow Tesla by 2025. Sanyal, S. (2022).	Article	Analytics Insight			✓	✓		✓			✓	
Attitudes and concerns on automated vehicles. Liljamo, T., Liimatainen, H., & Pöllänen, M. (2018).	Research Paper	Transportation research part F: traffic psychology and behaviour	✓			✓			✓		✓	
Ethical decision making behind the wheel–a driving simulator study. Samuel, S., Yahoodik, S., Yamani, Y., Valluru, K., & Fisher, D. L. (2020).	Research Paper	Transportation research interdisciplinary perspectives		✓			✓	✓				✓
Modelling and Simulation of an Autonomous Vehicle Ethical Steering Control System (ESCS). D'Souza, J., Burnham, K. J., & Pickering, J. E. (2022).	Research Paper	International Conference on Methods and Models in Automation and Robotics (MMAR) IEEE		✓			✓		✓			✓
Autonomous vehicle simulation for Asia	Research	International	✓				✓		✓	✓		

Title	Category	Source	Focus Area			Context		Data Type		Methodology		
			Social/Technical Ethical Challenges	Ethical Frameworks	Automotive Vehicle Market in India	Indian	Foreign	Qualitative	Quantitative	Exploratory	Descriptive	Analytical
urban areas with a perspective from education. Wang, S. H., Lin, C. X., Tu, C. H., Huang, C. C. J., & Juang, J. C. (2020).	Paper	Computer Symposium (ICS) IEEE										
Autonomous vehicle as a future mode of transport in India: analyzing the perception, opportunities and hurdles. Jana, A., Sarkar, A., Kallakurchi, J. V., & Kumar, S. (2019).	Research Paper	Eastern Asia Society for Transportation Studies			✓	✓			✓			✓
A study on implementing autonomous intra-city public transport system in developing countries-India. Thomas, A., & Trost, J. (2017).	Research Paper	Procedia computer science			✓	✓		✓		✓		
Anticipating Legal Issues Associated with the Cyber Security and Privacy of Automated Driving Systems in India. In Autonomous Driving and Advanced Driver-Assistance Systems (ADAS) Bali, S., & Sharma, S. (2021).	Research Paper	CRC Press.			✓	✓		✓				✓
Why self-driving cars are still a distant dream for India, Katyal, N. (2021).	Article	Business Today			✓	✓		✓			✓	
European Union regulations on algorithmic decision-making and a “right to explanation”. Goodman, B., & Flaxman, S. (2017).	Research Paper	AI magazine	✓				✓	✓				✓
Advanced driver assistance systems from autonomous to a cooperative approach. Piao, J., & Mc Donald, M. (2008).	Research Paper	Transport reviews	✓				✓	✓			✓	

Title	Category	Source	Focus Area			Context		Data Type		Methodology		
			Social/Technical Ethical Challenges	Ethical Frameworks	Automotive Vehicle Market in India	Indian	Foreign	Qualitative	Quantitative	Exploratory	Descriptive	Analytical
Why a right to an explanation of automated decision-making does not exist in the general data protection regulation. Wachter, S., Mittelstadt, B., & Floridi, L. (2017)	Research Paper	International Data Privacy Law	✓				✓	✓				✓

The present literature review is undertaken by first summarizing the research done on the RoboEthics in AVs sector, then outlining the Social/Technical Ethical Challenges faced by AVs, then moving on to the Ethical Framework that may be employed by AVs, and finally analysing the AV Market in India.

4.2 Thematic organization of literature review

4.2.1 RoboEthics in Autonomous Vehicles (AVs)

Roboethics is a field of study that examines the ethical and moral implications of robotics and artificial intelligence (AI). As the development of autonomous vehicles (AVs) has progressed, there has been an increasing interest in exploring the ethical implications of these vehicles. There have been several international conferences on Roboethics and the evolution of AVs over the years that have addressed the ethical, social, and legal implications of this emerging technology. Here are some examples:

I. The IEEE International Symposium on Ethics in Engineering, Science, and Technology (ETHICS) has played a pivotal role in addressing the ethical challenges associated with Autonomous Vehicles (AVs) since 2016. It serves as a prominent platform for global discussions on AV ethics, bringing together experts from diverse backgrounds such as from academia, industry, and government to discuss issues such as safety, privacy, and liability. ETHICS has made significant strides by encouraging interdisciplinary dialogues and contributing to the development of ethical guidelines for AV technology.

II. International Conference on Robotics and Automation (ICRA): ICRA, an annual international conference since 1984, has traditionally been a foremost gathering for the robotics and automation community. In recent years, it has broadened its scope to encompass discussions on roboethics and the ethical dimensions of Autonomous Vehicles (AVs). ICRA's adaptation to include roboethics signifies the growing recognition of the ethical facets of autonomous systems, particularly AVs. The conference now features workshops and panels dedicated to exploring ethical and legal considerations related to AV technology. For instance, in the 2021 conference, ICRA organized a workshop titled "Ethical and Legal Considerations for Autonomous Driving." This workshop explored ethical and legal dimensions relevant to AVs, demonstrating the conference's commitment to examining the broader ethical landscape of robotics and automation.

III. The International Symposium on Robotics Research (ISRR): ISRR stands as a prominent event

for showcasing and advancing cutting-edge robotics research globally. In recent years, ISRR has notably expanded its focus to include ethical considerations within the field of robotics. This development reflects the growing recognition that as robotics technology becomes more integrated into various aspects of society, addressing ethical issues is of paramount importance. ISRR has played a pivotal role in acknowledging the ethical dimensions of robotics research and development.

IV. Roboethics Symposium: This symposium is organized by the European Robotics Research Network (EURON) and has been held annually since 2004. The symposium brings together experts from academia, industry, and policymakers to discuss the ethical implications of robotics and AI, including AVs. In 2021, the symposium included a panel on "Roboethics and the Challenges of Autonomous Driving" that explored the ethical challenges of AVs.

V. Autonomous Vehicle Symposium: This annual conference is organized by the Association for Unmanned Vehicle Systems International (AUVSI) and is one of the largest conferences on AVs in the world. The conference includes panels and sessions on a wide range of topics related to AVs, including roboethics, policy, and regulation.

In spite of the valuable and significant contributions made by conferences and symposiums, which emphasize the growing awareness of the ethical and societal implications of Autonomous Vehicles (AVs), there are research gaps in how these conferences and symposiums address ethical considerations in the field:

1. **Standardized Ethical Frameworks:** There is a need for standardized and comprehensive ethical frameworks tailored specifically to AVs. A cohesive framework could provide guidance for responsible AV development and deployment.

2. **Comprehensive Societal Implications:** Ethical interdisciplinary discussions should expand beyond technical aspects to encompass broader societal implications, including the impact of AVs on employment, urban planning, and accessibility. A more holistic examination is needed.

3. **Inclusion of Public Perspectives:** Ensuring inclusivity by systematically incorporating public perspectives in ethical discussions is vital. Public attitudes and concerns regarding AV ethics need to be more comprehensively integrated into the research discourse.

4. **Adaptability to Emerging Challenges:** The necessity for adaptability to address evolving ethical

challenges arising from the continuous development of AV technology. These challenges may include decision-making in emergency scenarios and accountability for AV-driven systems.

The present research aims to explore the implementation of RoboEthics in the AV sector, an area that has not been extensively studied. Thus, one of the objectives of this present research emerges:

Objective 1- To understand the current status of RoboEthics in the AV sector globally.

4.2.2 Ethical Social/Technical Challenges Related to AVs in Real-World Environment

The present section highlights the various challenges observed in the literature review. First, the Social Challenges are discussed followed by Technical Challenges. A diagrammatic representation is enclosed in Figure 1

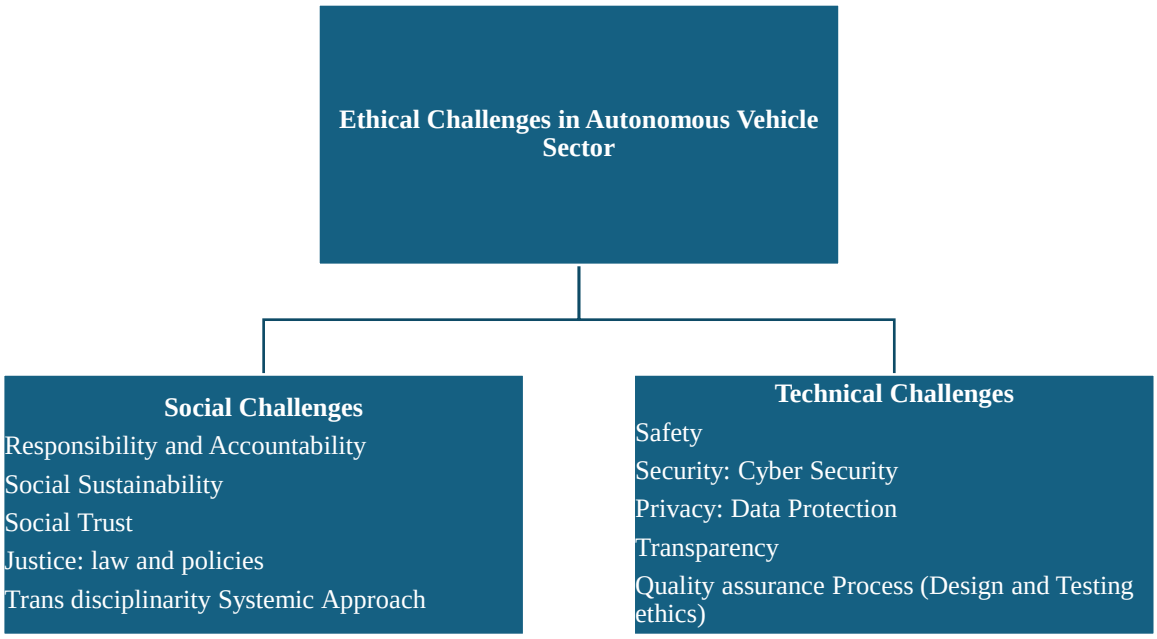

Fig. 1: Ethical Challenges in Autonomous Vehicle Sector

Holstein et al. (2021) studied ethical issues using a hybrid interdisciplinary methodology to obtain better data for enhancing real-world AV systems. In order to be effectively addressed, a number of practical ethical challenges related to safety, security, privacy, cybersecurity, transparency (algorithmic and social fairness), responsibility, and accountability have arisen as a result of the development and widespread usage of AVs. These issues also entail a trans-disciplinary systemic approach (including stakeholders),

social trust, quality assurance, environmental sustainability and Justice: norms, regulations, and guidelines.

Social Challenges

Responsibility and Accountability

The concepts of "responsibility" and "accountability" imply the duty to stand up for and justify one's decisions and deeds. The researchers Charisi *et al.* (2017) investigated the ethical behaviour of AVs, their ethical design, and their ethical implementation with Transparency and Accountability that all stakeholders, including the manufacturers, the users, and the various societal regulatory authorities, need to play their part in figuring out what is the best ethical behaviour for autonomous systems. While the possibility that how automation is perceived, experienced and used varies depending on cultural context, Coeckelbergh (2016) emphasised the accountability and social-relational difficulties that could limit the responsible use of AVs for all stakeholders while considering cultural norms.

Social Sustainability

Alavi *et al.* (2017) investigated the impact of AV ethical issues on society, resulting in fewer cars with a sustainable future to improve the comfort of pedestrians. The outcomes of these investigations would be multimodality, less traffic, better cities, less urban sprawl, and more sustainability measures (Liljamo, Liimatainen & Pöllänen,2018). Utilizing four dimensions—changes to experiences, inequalities, labour, and systems—Bissell *et al.* (2020) provided a summary of the wide range of social implications of autonomous vehicles. They attempted to address social issues by raising questions about how people will act in cities and on the roads when connected autonomous vehicles are present, as well as how workforces will adapt to produce new skill sets or lose their jobs as a result of the development of autonomous vehicles (AV). Bagloee *et al.* (2016) offered a complete viewpoint on issues related to social ethics and machine ethics in light of the growth in the application area and opportunity of autonomous vehicle (AV) technology. In this study, they provided a framework for integrating autonomous vehicles (AV) with conventional cars in traffic scenarios (non-AVs). They also provided a solution to some of the many ethical issues related to standards, planning, policy, communication technologies, societal effects, and client acceptance.

Social Trust

The ethical issue of trust manifests itself in different ways in AVs, including the use of the car and its hardware and software components. According to Hleg (2019), a variety of standards, such as accountability, transparency, diversity, non-discrimination, and justice, could be fulfilled in order to increase social confidence. Atiyeh (2015) focused on the critical ethical issue of "Trust" in his article and mentioned that automakers like Mercedes-Benz, Google, and Volvo would take full responsibility if their vehicles were involved in accidents while in autonomous mode. This would boost end users' confidence in AVs. By addressing the moral conundrum of operating a vehicle in an unpredictable environment, such as the "trolly problem," and emphasizing the development and effective use of AV technology through education and awareness, Beard (2019) sought to solve the ethical problems of safety and trust.

Justice: Legislation, Standards, and Guidelines

Legislation needs to be updated on a regular basis as connected and highly autonomous vehicles are developed ranging from completely non-autonomous (level 0) to fully autonomous (level 5) (Ethics Commission, 2017; Borenstein, Herkert, & Miller,2017). It has been noted by the National Highway Traffic Safety Administration that state regulatory frameworks and existing legislation for human-controlled vehicles will not be adequate for autonomous vehicles (NHTSA, 2020). Therefore, it became vital to continually evaluate and update its laws in order to provide authoritative standards that address the issues with autonomous vehicles as technology advances. By 2025, it will be necessary to address any potential ethical and legal challenges and benefits related to the use and implementation of AVs. To do this, a framework built on learning from experience and a scenario approach would be needed (Ryan, 2020). Wang *et al.* (2020) used a simulation platform to research various aspects of AV development and application. The 3D scooter simulation environment was employed by Taiwan's car lab in hectic urban traffic situations with various unique scenarios where two-wheeled vehicles and other non-autonomous vehicles were present. This 3D simulation-based development platform will aid in the creation and testing of Level 4 and Level 5 government-certified autonomous vehicle driving technologies as well as the collision avoidance algorithms for AVs.

The Declaration of Amsterdam (Ministry of Infrastructure & Environment, Netherlands, 2017) discusses worldwide testing for developing technologies as well as legal frameworks, data use, responsibility, and

sharing. It establishes a framework for the use of connected and autonomous vehicles throughout Europe (Ethics Commission, 2017; Borenstein *et al*., 2019). Santoni de Sio (2016) used anticipatory analysis in their study on Value Sensitive Design, Meaningful Human Control, Moral and Legal Obligations, and Specific Testing Zones for AVs to look at these and other subjects that could help with the transition to higher levels of autonomous. The responsibilities of stakeholders are also considered.

Transdisciplinary - Systemic approach (Stakeholders Involvement)

The development of AV technologies requires cross-disciplinary collaboration across a variety of involved parties (Stakeholders), disciplines, and stages in the design, development, implementation, testing, verification, maintenance, etc. As AV decisions are made, stakeholder concerns must be taken into account. Even if computer decisions may be better than human ones due to potential flaws, they may also be worse. (Eckstein and Schwalm, 2016). Hence, deciding how much control a person should have is crucial. How many alternatives clients will have when using the AVs control, route planning, and other services is the question that emerges in this context (Holstein *et al*., 2018). For instance, Tesla offers many default settings for autopilot (Tesla, 2018), which indicate various actions regarding speed and lane change recommendations.

Technical Challenges

Safety

The most crucial factor for AVs is safety. Many standards, including ISO 26262, describe the safety requirements for road vehicles. The development of AV standards is now underway, and they are based on research and testing. For instance, without a single accident, Google Waymo cars have covered 10 million miles (Hersman, 2019). In order to protect human life, Lin (2016) emphasised that Automotive Driving Systems (ADS) must make moral as well as ethical judgements and employ collision optimization algorithms. Using pedestrian-detecting technology on AVs was recommended by a study that examined how many pedestrian deaths could have been avoided by using AVs (Piao& McDonald, 2008).

Martinho et al. (2021) investigated safety and security as ethical concerns and the variations in how businesses operate in the Autonomous Vehicles (AVs) field. They did this by using academic research and industry reports as their primary sources. In the explanation of machine ethics and discussion of its

application, Goodall (2014a, 2014b, 2016a, 2016b) outlined moral behaviour for an Autonomous vehicle. He proposed a three-phase strategy for risk assessment/management by AVs, with acceptance by a human driver at the time of decisions, that combines a rational ethics approach, an artificial intelligence approach, and a demand for natural language. Additionally, he advised obtaining a variety of societal values based on the scenarios and encoding these values into machine language so AVs can interpret and foresee alternative crash courses with the least amount of damage/collision.

Security - Cyber Security

For Autonomous Vehicles (AVs), security is of uppermost importance, as per UK's Department for Transport (2017) manufacturers/ Organizations need to own, govern and promote/protect AV systems and ensure systems are secure over their lifetime. Liu *et al*. (2020) used qualitative research and thematic analysis and observed cyber security and privacy as ethical challenges associated with AVs that need to be addressed before a full-scale launch.

Privacy-Data Protection

The likelihood that data and privacy protection will be breached increases as more information is taken into account when making a decision. It raises concerns and was discussed by Wachter, Mittelstadt and Floridi (2017) to provide a legal framework to safeguard personal data if the data is gathered, reported, and/or shared without the users' consent.

Transparency

Transparency is a prerequisite for many of the issues that have already been brought up. Transparency is crucial for autonomous vehicle development to be morally acceptable (McBride,2016; Goodman and Flaxman, 2017). Manufacturers are required by law to submit a Report of a Traffic Accident Involving an Autonomous Vehicle to the Department of Motor Vehicles within 10 working days after the occurrence, as per the testing parameters, according to the Department of Motor Vehicles (State of California, Department of Motor Vehicles, 2020). Gleadow (2022) emphasises integrating accountability, safety, transparency, and sustainability into the designing, development, and deployment of AVs on local roads. Transparency is a crucial prerequisite for the ethical development of this technology.

Quality Assurance Process

To assure high-quality components that pose ethical issues, a strong quality assurance (QA) program encompassing all pertinent activities throughout an AV's lifespan must be developed (Sapienza, DodigCrnkovic, & Crnkovic, 2016). A normal premium non-autonomous vehicle includes more than 100 electronic control units that are in charge of controlling things like the engine, navigation system, or dashboard, which makes it extremely complicated. Complexity will increase when AV technology becomes available (Pelliccione *et al.*, 2017).

Since the literature on AVs which form a sub-component of the automotive sector was not observed to be found in the Indian context the next objective of the present study emerges:

Objective 2 - To understand the ethical challenges of implementing AVs in the Indian Markets.

4.2.3 Ethical Frameworks potentially to be used while designing AVs

1. Bonnefon *et al.* (2016) investigated many ethical frameworks in an effort to determine which one would work best for automated vehicles. They discovered that moral algorithms would lead to a social conundrum by demonstrating how utilitarian autonomous vehicles (AVs) would sacrifice their passengers for the greater good in order to reduce the number of fatalities on the road, but everyone would rather ride in AVs that protect their passengers at all costs.
2. D'Souza, Burnham, and Pickering (2022) studied a vehicle ethical steering control system (ESCS) for autonomous vehicles (AVs) using modelling and simulation tools with a utilitarian ethical approach as the main focus, i.e., steering into the path of least injury severity. It would be engaged if inevitable collisions were discovered and a choice needed to be taken regarding the choice of a collision target.
3. Samuel *et al.* (2020) studied ethical decision-making in inevitable situations using a survey method based on driving simulators. In order to avoid hitting a large group (5) of pedestrians, 63% of participants manoeuvred their car towards an area with few or no (1) pedestrians. This suggests that while people frequently choose utilitarian decisions, they often struggle to make them in simulated driving environments under a time constraint that is approximate to the time they would have to make the same decision in the real world (2s). which directly calls into question the ability of algorithms in autonomous vehicles to assist in decision-making on our behalf when a driver lacks sufficient time to reach a moral conclusion.

4. Nyholm & Smids (2018) investigated the 2016 and 2018 autonomous vehicle accidents involving Google's self-driving vehicles, Tesla Model S, and Uber's self-driving cars that resulted in fatalities and bring attention to having the same globalised "ethical settings" to make decisions in real-world ethical dilemmas. They also addressed ethical theories such as utilitarianism, Kantianism, virtue ethics, and contractually suggest how automobiles should approach crash circumstances.
5. Karnouskos (2018) explored and examined the range of unavoidable accidents by addressing the issues of the impact of various ethical frameworks on controlling AV decision-making and anticipated the impact of several ethical frameworks: utilitarianism, deontology, relativism, absolutism (monism), and pluralism, on their acceptability by multiple stakeholders. He claimed that all five ethical frameworks will have an impact on autonomous vehicle adoption, which implies several stakeholders as it is a deciding factor for the success or failure of the introduction of AVs to the market.
6. Esch (2021) employed quantitative analysis and post-hoc interviews to evaluate the effects of ethical frameworks like utilitarianism, egoism, altruism, and deontology on the decision-making algorithms of fully autonomous AVs (level 5), on user acceptance/adoption of such technologies, in the case of an inevitable accident. However, the researcher was unable to select a particular ethical framework that appears to be most suitable for such vehicles and instead suggested exploring the topic.
7. Arfini *et al.* (2022) observed autonomous Vehicles (AV) in a no-win Dilemma and attempted to address the choices that AVs are programmed to make by recommending the adoption of a combination of ethical theories - utilitarianism and deontology - as well as providing manufacturers and end-users/AVs consumers with the right to choose ethical policies that better fit their moral attitudes.

Fig. 2 Ethical Frameworks

As an outcome of the absence of ethical framework literature in the Indian context, the following objective of the present research emerges:

Objective 3: To study ethical frameworks in AVs utilising simulation tools while keeping the Indian Transportation System in mind

4.2.4 Development of the AV Market in India

How quickly a new technology is adopted is significantly influenced by the attitudes and mindsets of the general populace. Autonomous Vehicles (AVs) across six countries: China, India, Japan, the USA, the UK, and Australia. The survey, which involved 500 respondents from each nation, focused on gauging people's thoughts, interests, and concerns regarding AV utilization. The survey results revealed a prevailing favourable sentiment toward AVs among the public. However, this positivity was tempered

by notable apprehensions regarding the safety and security of these vehicles. Specifically, individuals in China and India exhibited a remarkably high level of interest in AVs, with an impressive 85% of respondents expressing a positive view. In contrast, Japan presented a unique scenario, with 50% of respondents indicating no clear opinion on AVs. In the USA, 16% of respondents held an unfavourable or somewhat negative attitude toward AVs. Hence, survey-based approach stands as a credible and accepted method for capturing public perspectives, shedding light on the global landscape of attitudes toward AVs, and highlighting the need for further examination of regional nuances in perception and concerns.In order to analyse the adoption of AV in India, Jana et al. (2019) conducted an exploratory survey in major Indian cities, including Mumbai, Hyderabad, Pune, Delhi, and Chennai, targeting university students and corporate executives. The survey revealed a favourable view of Autonomous Vehicles (AVs) among respondents, regardless of gender. However, concerns were raised about safety, security, and cost, identified as significant barriers to AV adoption in India. This aligns with prior research by Thomas and Trost (2017). Overall, the study highlights India's generally positive perception of AVs while emphasizing the need to address specific concerns for widespread adoption.

With the introduction of Autonomous vehicles on Indian roadways, Bali and Sharma (2021) explored the impact on the Indian legal system, encompassing data privacy, motor vehicle actions, and cybersecurity actions, due to the absence of regulations governing Autonomous Vehicles (AVs). The study employed case studies covering liability, malfunction from Indian traffic data exposure, accidents caused by vehicle hacking, and personal data protection. The research emphasized the need for a comprehensive review of regulations in India, highlighting the current absence of legal conventions or legislation addressing AVs. Daily *et al.* (2017) examined recent technological breakthroughs, their impact on social reform, and improvements to the efficiency and security of our road and transportation networks. For the Indian market, TATA Motors and Mahindra are progressing in the creation of commercially viable autonomous driving technologies that are pertinent to regional circumstances. Anand (2019) investigated the future aspect of autonomous vehicles for the transport network and analyzed the benefits of AVs in the Indian context, including higher personal productivity, better on-road safety, more efficient cars, and better utilisation of existing road capacity. Anand also investigated how state transportation authorities could utilize a large quantity of information for vehicle and

passenger safety as well as the technological, cultural and vehicle infrastructure challenges they encounter.

In his study, Katyal (2021) outlined the obstacles that India must overcome before autonomous cars can be introduced in the nation. These obstacles include the high cost and financial instability of introducing AVs in India, the unemployment of conventional drivers, and the absence of standardisation in the country's road infrastructure and network. Regardless of the challenges, companies such as Flux Auto, Mahindra & Mahindra, and Escorts are ready to deploy AVs. In her article, Sanyal (2022) examined the emergence of new Autonomous Vehicle (AV) firms in the Indian automotive sector, driving innovation in AV development. Notable companies include Flux Auto, focused on ensuring safe AV operation in real-world conditions; Scouto, employing Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication; Swaayatt Robotics, specializing in interconnected autonomous driving technology; Minus Zero, known for prototyping fully autonomous vehicles for Indian roads; Netradyne, leveraging computer vision and data analysis for transportation advancements; Fisheyebox, pioneering AI-driven manufacturing; AutoNxt, combining high-torque electric powertrains with off-road AV technology; and Hi-Tech Robotic Systemz, dedicated to advancing AV and driverless technology with cutting-edge equipment. The involvement of Indian tech firms in the global development of AutonomousVehicle Technologies was examined by Gupta (2023). For international automakers, approximately 35% of the 100 million lines of code needed to create one fully AutonomousVehicle are being written by engineers located in India. These engineers have also trained and tested their cloud-based AV platforms using more than 300,000 kilometres of real-time vehicle data from various geographic locations. Automobile Manufacturers receive services from tech firms like Tata ELXSI, TCS, Tech Mahindra, and HCL Technologies, which also assists them in putting their next-generation vehicles on the road.

4.3 Summary of Research Gap

The following research gaps were identified from the literature review.

1. Systematic analysis of software-hardware systems must be performed in context-specific settings as opposed to in isolation, which cannot guarantee the resolution of social and technological ethical issues.

2. Global Framework for the driving style of both human-driven cars and AVs to optimise risk management
3. Responsibility and Retribution gaps by all stakeholders collectively (AV manufacturers, Original Equipment Manufacturers (OEM) and End users (drivers)).
4. Exploring Ethical Challenges keeping different countries, and geographic regions and evaluating the country-specific characteristics of the issues associated with AVs.
5. Exploring the Ethical Framework which will lead to success or failure and user acceptance, in the case of unavoidable, decision-making.
6. Development and Evaluation of Indian laws, rules, or regulations governing autonomous vehicles.
7. Due to less on less evidence on the ethical issue in society. So, a study needs to be done to understand the ethical value of autonomous cars in the context of urbanity.
8. Challenge for a policymaker is to make a common framework for autonomous vehicles (AV) in traffic scenarios with conventional vehicles (non-AVs) as well as point towards providinga framework for a traffic network to connect several intelligent vehicles.
9. It indicates stakeholder behaviour toward the concerns of safety, security, trust, privacy, and dependability that must be handled when information transferred, monitored, and processed is down with AV device-to-device (D2D) communication scenarios.
10. Lack of adequate literature regarding AV emergence, usage and user perception concerning AVs in the Indian scenario.

5. CONCEPTUAL FRAMEWORK

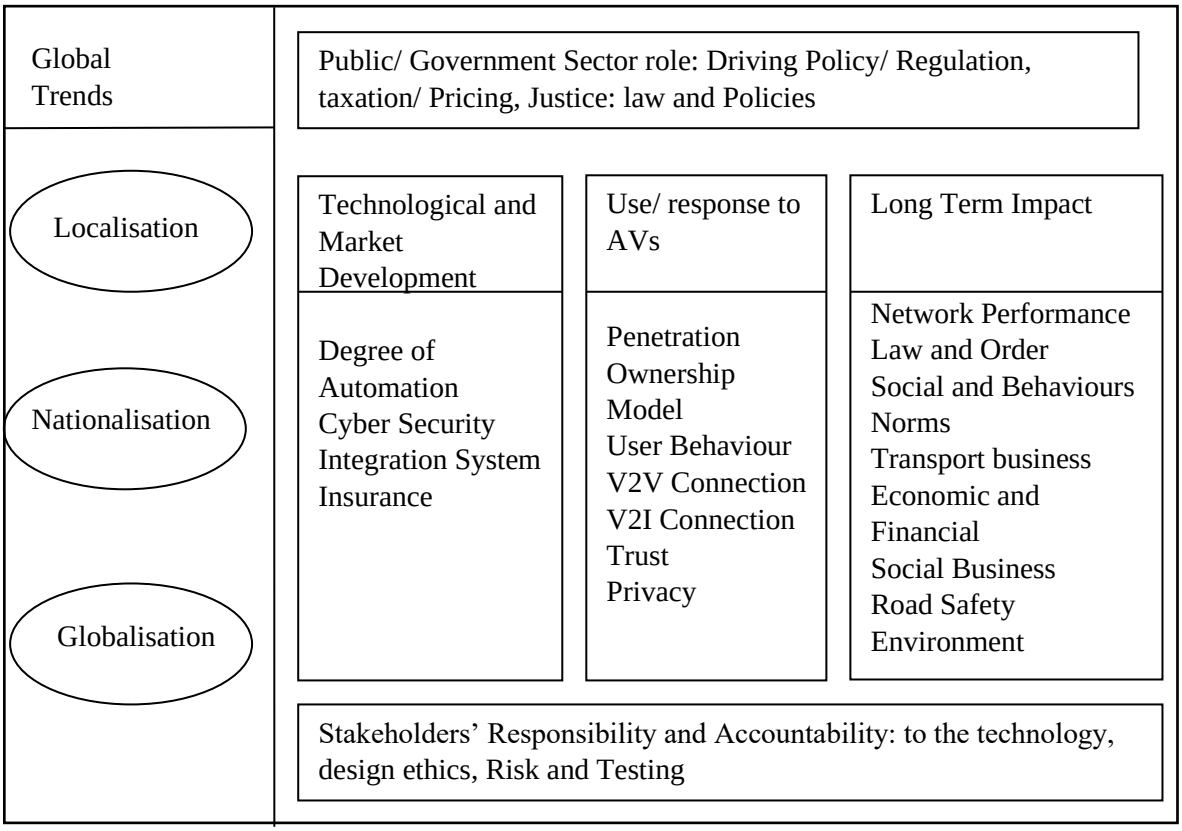

Fig. 3 CONCEPTUAL FRAMEWORK for AVs

In this section, a diagram of the factor affecting/ethical challenges for AVs in the automotive industry is discussed which will be undertaken in the present study.

Global Trends: - Current Trends prevailing in Local; National and Global drives running**.**

Public/ Government Sector role: - Driving Policy/Regulation, Taxation/Pricing, Justice: law and policies

Stakeholders' Responsibility and Accountability: to the technology, Design Ethics, Risk and Testing

Technological and Market Development: - Degree in Automation; Cyber Security; Integration System; Insurance

Use / response to AVs: - Penetration; Ownership model; User behaviour; V2V connection; V2I connection; Trust; Privacy

Long Term Impact: - Network Performance; Law and Order; Social and behavioural norms; Transport business; Economic and financial; social business; road safety; environment

6. OVERVIEW OF THE PROPOSED RESEARCH

6.1 Introduction

This research is a comprehensive exploration of the ethical dimensions entailed in the integration of Autonomous Vehicles (AVs) into the Indian market. It is structured into three interrelated phases, each addressing distinct facets of this pressing issue.

6.2 Need of the Study

The rationale for this research is rooted in the ever-evolving landscape of AVs and their imminent presence in India. The study identifies and addresses three fundamental needs:

A. Understanding Global RoboEthics: The first imperative is to gain comprehensive insights into the existing state of RoboEthics within the global AV sector. This foundational understanding serves as a stepping stone for grasping ethical considerations that transcend geographical boundaries and exert a significant influence on AV development across the globe.

B. Exploring Ethical Challenges in the Indian AV Market: The second need is to delve deep into the intricate ethical dilemmas that surface as AVs make their mark in the Indian market. With a particular focus on ethical predicaments confronted by AV users in India, this phase seeks to unravel the complex interplay of technology and morality within the Indian context.

C. Analyzing Ethical Frameworks for India's Transportation Landscape: The third requirement involves a rigorous examination of ethical frameworks meticulously tailored to align with the intricacies of the Indian Transportation System. Achieved through sophisticated simulation tools, this phase envisions how these frameworks can effectively guide ethical decision-making within India's multifaceted transport ecosystem.

6.3 Objectives of the Proposed Research

The research objectives are thoughtfully crafted to seamlessly align with the overarching needs of the study:

1. To understand the current status of RoboEthics in the AV sector.
2. To understand the ethical challenges of implementing AVs in the Indian Markets (customer perspective).
3. To study ethical frameworks utilising simulation tools while keeping the Indian Transportation

System in mind.

7. RESEARCH METHODOLOGY.

7.1. Scope of the Study

The proposed research explores RoboEthics in the autonomous vehicle (AV) industry, with an emphasis on the Indian automotive market. From both a global and customer viewpoint, the study seeks to provide a thorough grasp of the ethical issues and difficulties related to the implementation of AVs in India.

7.2. Instruments/ Techniques to be Used

The proposed study would use a variety of methodologies, including a thorough literature review, questionnaires, and simulation tools, to collect both qualitative and quantitative data. Questionnaire surveys and simulation tools will be utilized to collect quantitative data. Additionally, a thorough assessment of the literature will be done to compile the findings and knowledge currently available regarding RoboEthics in the AV sector.

7.3. Statistical Measurements-

Table 3: Research Methodology

Primary Objectives	Research design	Data Source / Collection	Data Analysis
To understand the current status of RoboEthics in the AV sector globally.	Analytical Research Design	Secondary data source (Online platforms, Journal articles, and social media among others)	Content analysis
To understand the ethical challenges of implementing AVs in the Indian Markets (customer perspective).	Exploratory Research Design	Primary data source	Quantitative analysis
To study ethical frameworks utilising simulation tools while keeping the Indian Transportation System in mind.	Experimental Research Design (difference in post-test across different frameworks)	Simulation exercise	Comparative analysis

- **Objective 1: To understand the current status of RoboEthics in the AV sector globally.**
- Type of research: Analytical Research Design
- Type of data: Secondary data
- Source of Data:
- Academic journals: scholarly publications in areas including ethics, artificial intelligence, and

robotics. This will offer in-depth analyses and professional viewpoints.

- Reports: Publications from the government, the business world, and organizations that deal with ethics and autonomous vehicles.
- Websites: The official websites of autonomous vehicle development organizations, AV Communities, Group or Club committees, and pertinent government entities.
- Tools for Analysis: Content Analysis: Once the data is coded and classified, further tools for non-parametric / categorical data may be used, depending on the type of data.
- **Objective 2: To understand the ethical challenges of implementing AVs in the Indian Markets (customer perspective)**
- Type of research: Exploratory Research Design
- Type of data: Primary data
- Source of Data: A survey will be created to gather primary data from a variety of stakeholders, such as AV users, policymakers, business leaders, as well as relevant professionals in the Indian market.
- Sample:
    - n = (Z^2 * p * q) / E^2

      Where:

        - n is the required sample size.
        - Z is the desired confidence level (set at 1.96 for a 95% confidence level).
        - p is the estimated proportion (assumed to be 0.5).
        - q is the complement of p (q = 0.5).
        - E is the desired margin of error (set at ±5% for true population value, E = 0.05).
        - n= (1.96) ^2 * (0.5) (0.5)/ (0.05) ^2= 384
- Sample composition

Data will be acquired through structured questionnaires for rigorous quantitative analysis, involving a diverse group of participants. This inclusive group encompasses prospective AV enthusiasts, industry stalwarts, transportation experts, and ethics authorities. Prospective AV enthusiasts offer insights into AV anticipation, notwithstanding its nascent presence in India. Additionally, participants well-versed in

AVs, ethics, transportation systems, and related domains will be considered. To ensure a representative sample, diversity across demographics such as gender, age, education, and geographical location will be emphasized. This comprehensive approach strives to gain a holistic understanding of the ethical challenges foreseen by various customer segments in the Indian AV market, encompassing both the current scenario and future potential.

- Sampling Techniques

In order to comprehend the ethical challenges within the Indian Autonomous Vehicle (AV) market, a comprehensive and systematic sampling technique will be employed focusing on the Delhi-Agra Region. Employing an equitable allocation strategy, we will randomly select 192 participants from both male and female subgroups within the Delhi-Agra Region, resulting in a total of 384 participants. This ensures a well-rounded representation of gender perspectives. With a total sample size of 384 participants, carefully chosen from the Delhi-Agra Region, we aim to capture a comprehensive array of viewpoints. The final sample, will be meticulously designed to mirror the population distribution within each stratum, guaranteeing a well-balanced and representative dataset for a thorough investigation into the ethical challenges encountered in the Indian AV market.

- Tool for data collection: Questionnaire (Self Structured)
- Tools for Analysis:Quantitative research: Descriptive and Analytical tools will be employed to analyze the survey data.
- Ethical Consideration: Informed consent is to be taken from the participants of the study.
- A Prioritization of Ethical Challenges will be done subsequently using Nominal Group Technique (NGT) and Systems Thinking methodologies.
- **Objective 3: To study ethical frameworks utilizing simulation tools while keeping the Indian Transportation System in mind.**
- Type of research: Experimental research design (Investigating the difference in post-test acerose using different frameworks)
- Type of Data: Simulation Exercise
- Source of Data: Simulation software like CARLA (Car Learning to Act) or other comparable

platforms

- Tool for data collection: Simulation software
- Tools for Analysis: Comparative analysis of various ethical frameworks in the Indian context.

8. PROPOSED CHAPTERIZATION

The proposed research will contain the following chapters:

- Chapter 1: Introduction
- Chapter 2: Review of literature and Theoretical framework
- Chapter 3: Research Methodology
- Chapter 4: Current Status of RoboEthics in the AV Sector
- Chapter 5: Customer Perspectives on AV Ethics in India
- Chapter 6: Findings from Simulation Studies
- Conclusion and Recommendations
- References
- Annextures

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